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HISTORY OF THE MK 40 WARHEAD (U)

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Weapon Systems

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had been proposed, including the Mks 7, 12 and 30, but it was felt that they were too heavy for their yield.[2]

However, as missile design became more firm, the Air Force Special Weapons Center notified Sandia, December 12, 1955, that the missile would become operationally available July 1, 1959. It was felt that the warhead compartment of the BOMARC would be able to carry an atomic device with a diameter of 18 inches, and that space should be available for X-unit, gas-boosting equipment, and external initiator.

(b)(1), (b)(3)

Sandia replied December 28, 1955, stating that a 17-inch-diameter warhead could be developed, which would have a weight less than 300 pounds and the desired yield, and be able to survive the BOMARC's launching boost and cruising speed.

(b)(1), (b)(3)

Another missile came under consideration January 26, 1956, when the Assistant Secretary of Defense wrote to the U. S. Atomic Energy Commission, noting that the Army was developing the LACROSSE missile and hoped to achieve an atomic capability.[5] The LACROSSE had a 20.5-inch-diameter body which was 19 feet long and weighed 2350 pounds at launch. It had a wingspan of 9 feet, two main swept-back wings, and a 4-fin tail. The initial launching boost, as well as flight power, was provided by a solid-fuel rocket which produced a missile speed of Mach 1.5.

The LACROSSE was a surface-to-surface missile designed for precision delivery against land targets under direct observation in close support situations. The missile was launched from a 2-1/2-ton Army truck located from 8,000 to 30,000 meters from the target (5 to 18.5 miles). The missile was launched in the general direction of the target and flew at altitudes between 5,000 and 13,000 feet above the launching point. It was acquired in flight by a jeep-transported forward guidance station and guided to the target by radio and optical techniques.

(b)(1), (b)(3)

A feasibility study of possible warheads for the LACROSSE missile was completed by Sandia and forwarded to Albuquerque Operations Office June 6, 1956.

(b)(1), (b)(3)

Both these warheads could be made available by April 1959.[11]

By mid-1956 the design of the XW-40 Warhead was taking shape. The warhead would be sealed and gas-boosted. The warhead electrical system was practically identical with the Mk 28 system, and used the same X-unit, removable high-voltage battery pack, dual external initiators, dual motor-operated arm/safe switches, gas-boosting mechanism, and dual cold-cathode thyratron trigger circuits.

(b)(3), (b)(1)

The warhead diameter would be slightly larger than desired, 17.9 inches, and the length would be 31.56 inches. It was expected that the weight could be held to 290 pounds. Only minor maintenance would be permitted in the field, since assembly or disassembly of the sealed warhead would require special tools. Positive safing during storage and handling was provided by removable batteries. The warhead would be pressurized with dry air or nitrogen.[13]

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The Army's Picatinny Arsenal had advocated that interface problems on the XW-40/LACROSSE be handled by the concerned project officers, rather than through a special joint committee, as had been the custom for previous weapons. It was suggested that the participating agencies each appoint a representative; with Sandia being responsible for the warhead, the Army responsible for the rest of the missile-warhead system, and the Armed Forces Special Weapons Project responsible for the interests of other military services.[17] This proposal was adopted.[18]

A third missile program was introduced when the Assistant Secretary of Defense wrote to the Atomic Energy Commission, September 19, 1956, requesting cooperation with the Navy in the feasibility study of a nuclear warhead for the CORVUS missile.[19] The CORVUS was an antiship, air-launched missile designed to home-in on enemy radar installations. The CORVUS was scheduled to be operationally deployed for evaluation in mid-1960, with delivery to the Fleet in April 1961. The missile would be carried by AD4-, A3D-, and P6M-type aircraft, which would launch the missile from a maximum standoff range of about 170 nautical miles.[20]

A working group was established, and Sandia studied the physical fit of several nuclear warhead designs in the CORVUS.[21] There were some warheads that could be

modified for such installation, but none met all the requirements established by the Navy Bureau of Aeronautics.

(b)(1), (b)(3)

An XW-40/CORVUS could be provided which would meet most of the Navy requirements, but modification of warhead case and missile compartment would be necessary. It was felt that this redesign might delay the release date of the warhead, currently estimated as January 1958, and affect its application to the BOMARC and LACROSSE.[22]

Work had meanwhile been proceeding on the design of the XW-40 Warhead. The high-voltage battery package would contain five batteries connected in series, with a pair of silicon diodes shunted across each set of battery terminals to allow normal operation of the other four batteries, should one unit fail. Thermal fuses would be located in the ground line to isolate the battery output in the event of fire. Dual squib transformers would be provided to minimize power requirements and to provide increased reliability and reduced size. The high-voltage arm/safe switches would be motor-driven and reversible, thus affording positive control. These switches were inherently fire-safe and could not be inadvertently operated by electromagnetic radiation.

The gap switch of the XW-40 could be fired by either of two methods. One was by a low-impedance source, provided by the adaption kit, with signals derived from timers, impact switches, or barometric switches. The other was by a high-impedance source, such as supplied by radar, thyratrons or contact crystals. This required the design of a 4-probe gap and four pulse-type firing transformers; two for the low-impedance and two for the high-impedance signals.

The use of the warhead in the air-defense BOMARC made it mandatory that the warhead components have low sensitivity to nuclear radiation.

(b)(3)

(b)(3)

Components that were squib-initiated or explosively operated were also sensitive to electromagnetic radiation and discharges of static electricity.[6]

Sandia notified Albuquerque Operations Office, February 5, 1957, that no approved military characteristics had been received for the XW-40 Warhead. It was estimated that flight tests of the warhead in both the BOMARC and LACROSSE would start by May 1957, with 15 flights being required to provide necessary environmental and systems operational data. The first squadron of BOMARC and LACROSSE missiles would not become operational until mid-1959, although the warhead would undoubtedly be available by this time.[23]

The Division of Military Application wrote to Albuquerque Operations Office March 6, 1957, noting that the operational availability date of the XW-40 Warhead had apparently slipped from January to July 1959, and requesting an explanation of the delay.[24] Albuquerque Operations referred the request to Sandia, noting that, if at all possible, the earlier date should be maintained. It was felt that warhead availability should not be tied to the date on which a missile squadron became operational.[25]

Sandia replied, April 10, 1957, that the latest flight-test schedule dates meant that the six required systems tests of the XW-40 Warhead in the BOMARC and LACROSSE missiles would not be completed until some time after January 1958. It was felt that at least nine missile flights would be required to provide six successful tests. Thus, a design-release date of July 1958 for the warhead and an operational-availability date of mid-1959 appeared to be logical.

(b)(1), (b)(3)

(b)(1), (b)(3)

Picatinny Arsenal had requested Sandia to prepare a contract covering flight-test telemetering and use of Sandia's sled track for contact-fuze tests of the XW-40/LACROSSE program. This contract was submitted to Albuquerque Operations Office April 12, 1957, and subsequently put into effect.[27] It had been decided that interface problems of the XW-40/BOMARC program would also be handled on a project-officer basis.[28]

(b)(1), (b)(3)

Approved military characteristics for the XW-40 Warhead were released by the Military Liaison Committee June 18, 1957. Warhead applications included BOMARC and LACROSSE missiles, as well as other applications that might be authorized by the Department of Defense. The parameters of the warhead would be held to a practicable minimum and would not exceed a diameter of 17.4 inches, length of 31.7 inches, and a weight of 300 pounds.

(b)(1), (b)(3)

Preliminary investigation had indicated the feasibility of incorporating such high-yield warheads in the BOMARC missile, and a study was requested.[30]

(b)(1), (b)(3)

Either design could be made operationally available by January 1962 without interference with existing work.[31] The project was subsequently canceled April 22, 1958, as it was felt that the XW-47 Warhead then being designed for the POLARIS missile would better satisfy the requirements.[32]

Sandia presented Report SC4071(TR), Proposed Ordnance Characteristics for the XW-40 Warhead, to the August 21, 1957 meeting of the Special Weapons Development Board.[33]

(b)(1), (b)(3)

The Board accepted the report and it was subsequently forwarded to the Division of Military Application.[35]

(b)(1), (b)(3)

The Assistant Secretary of Defense wrote to the Atomic Energy Commission November 13, 1957, noting that a joint feasibility study for a nuclear warhead for the CORVUS missile had been completed. The study had concluded that the XW-40 Warhead could be applied to the missile without change, and it was requested that design of the project be instituted, in cooperation with the Navy.[36]

Meanwhile, it had been decided that the BOMARC adaption kit would be provided by the Air Force. This kit would contain an arming and fuzing system, external power supply, and most of the self-destruct system. The safing and arming device was a limited integrating accelerometer. The kit contained an arming program that sequenced the input signals to the warhead and fuze.

The warhead would normally be detonated by its primary fuze, an electronic influence device. A secondary predictor-computer-type fuze would receive information from a target seeker and provide backup if the target did not come within firing range of the primary fuze.

(b)(3)

Boeing Airplane Company was supplying the adaption kit, and the Diamond Ordnance Fuze Laboratory was developing the arming and fuzing system.[1]

Field Command noted that the failure probability of 1 to 130 for the self-destruct system was far short of the 1 to 10,000 required by the military characteristics.[37] Sandia replied, February 12, 1958, stating that the warhead design was well along when the approved military characteristics were released, and that any appreciable gain in reliability could only be achieved through the use of dual systems. This would lengthen the warhead by 3 inches, increase its weight by 5 pounds, and require 6 months' additional development time. Since both BOMARC and LACROSSE missiles used ~~in~~ a single-channel self-destruct system, it appeared that this signal derivation could not approach the reliability requested.[38]

The Division of Military Application sent a teletype to the Albuquerque Operations Office March 31, 1958. Recent information had indicated an activation date of October 1959 for the first LACROSSE squadron, and it therefore appeared that a warhead operational availability date of July 1959 would be suitable.[39]

(b)(1), (b)(3)

agency was the Navy Bureau of Aeronautics, with the Bureau of Ordnance assisting in problems of fuzing, arming, self-destruction and warhead-missile compatibility.[50]

The Mk 40 Warhead was released for use in the BOMARC and LACROSSE June 30, 1959, and early production of the warhead occurred September 1959. Report SC4189(TR), Status at Complete Design Release and a Final Engineering Evaluation of the XW-40 Warhead,[51] was presented to the October 21, 1959 meeting of the Special Weapons Development Board. The warhead was 17.9 inches in diameter, 31.5 inches in length, and weighed 304 pounds. (b)(1), (b)(3)

The Board accepted the report for forwarding to the Division of Military Application.[53]

(b)(1), (b)(3)

(b)(1), (b)(3)

Normally, such a change would have required a new Mod number of the warhead. However, since only a few items had been produced, it was felt that adequate control could be maintained by serial number until all the warheads had been properly retrofitted.[54]

At this time, a proposal was made to incorporate an environmental safing device to provide increased safety in handling the Mk 40 Warhead. This device would be operated by the acceleration experienced by the warhead in the boost phase of the missile flight, and the Services were requested to provide the appropriate longitudinal accelerations.[55]

Sandia wrote to Field Command March 28, 1960, discussing current progress in the self-destruct system.

(b)(1), (b)(3)

To satisfy the military characteristics, development work had been started on a dual-channel charging and triggering circuit, but it was evident that these improved units would not become available until a substantial number of the Mk 40 Warheads had entered stockpile.

(b)(1), (b)(3)

Transistor production difficulties had delayed the firing sets,

action link or arming-control device to be incorporated into the LACROSSE application for an additional measure of command control. This would have created the Mk 40 Mod 3.[67] Subsequently, Albuquerque Operations Office sent a teletype to Sandia April 10, 1963, stating that the Division of Military Application had ordered suspension of activity on the Mk 40 Mod 1 and Mod 3 for LACROSSE, applying both to the environmental sensing device and prescribed action link.[68] Eventually, a few Mod 1's were produced and stockpiled in August 1964, but they were withdrawn several months later.

Design work continued on the Mk 40 Mod 2 for the BOMARC application.[69] A ground compatibility test was held, which disclosed electrical feedback through missile wiring from one motor-driven arm/safe switch to the other when the motor speeds were sufficiently different. This feedback caused a cyclic condition that caused the switches in some warheads and missiles to run abnormally long before stopping at their proper positions. Due to a difference in wiring, this problem applied only to the XM-99A or early BOMARC design.[70]

Sandia studied the situation and reported, May 27, 1963, that modification of the Mk 40 Warhead did not appear to be warranted, as the switch cycling was not caused by any warhead defect. It was pointed out that peacetime nuclear safety was not lowered, and that the total effect of the cycling on warhead safety was minor. The condition was dependent on the missile's being launched, the warhead's being fully armed, a failure of the system to detonate the warhead, and a failure of the self-destruction system. It was noted that, if all these events occurred, and the arm/safe switch failed to return to safe for any reason, including cycling, some nuclear yield might be produced when the warhead impacted the ground. It was suggested that warheads in stockpile be tested and that defective units be replaced.[71]

Mk 40 Mod 2 retrofit kits were subsequently stockpiled in December 1963 for use with the BOMARC missile.

Glossary of Mk 40 Terms

Accelerometer, Integrating -- A device for measuring acceleration, capable of summing the total acceleration in any given direction.

Adaption Kit -- Those items peculiar to the warhead installation less the warhead; namely, the arming and fuzing systems, power supply, and all hardware, adapters, and the like, required by a particular installation. Adaption-kit components are normally grouped into a complement, radars (if used), and power supply (if required).

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

Air Research and Development Command -- Established January 1950 by the Air Force to supervise efforts toward the accomplishment of the Air Force mission.

Albuquerque Operations Office -- The local office of the Atomic Energy Commission (AEC) concerned with the operations of Sandia Corporation.

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions related to atomic weapons.

Arming -- The act of arming a weapon, that is, preparing it for firing.

Assistant Secretary of Defense -- Created by Department of Defense directive, June 30, 1953, as part of DOD reorganization. Handles research and development activities of the DOD.

Barometric Switch (Baroswitch) -- A switch actuated by air pressure.

Boosting Gas -- Deuterium-tritium gas introduced into the implosion process to increase the fission activity and thus the yield of the device.

Bureau of Ordnance -- That part of the Navy Department having to do with design and procurement of ordnance.

Centrifuge -- A device employing centrifugal force and used to stress weapons and components. Consists of a horizontally mounted arm. The item to be tested is placed on one end of the arm and a rocket motor mounted on the other end. Firing the motor produces high rotational speed of the arm.

Contact Fuze -- A fuze that detonates the weapon by contact with the ground or the target.

Prescribed Action Link -- A device that prevents unauthorized activation of a nuclear device.

Primary -- A fission bomb that acts as the source of energy to start the secondary or thermonuclear reaction of a two-stage device.

Radar -- Named for Radio Detecting and Ranging. Radars emit a pulse of high-frequency energy and measure the time lapse from that transmission to receipt of a reflected electrical "echo" from an object. This time measurement determines the distance of the object from the transmitting antenna of the radar.

Reactor Products -- Nuclear material, especially uranium and plutonium.

Redwing -- A full-scale nuclear series of 17 tests held at the Pacific Proving Grounds from May 4 to July 21, 1956.

Reservoir -- As used in this history, a container for deuterium-tritium boosting gas.

Retrofit Kits -- A grouping of material and parts used to retrofit (retroactively outfit) a nuclear weapon.

(b)(1), (b)(3)

Thermal Battery -- A battery whose electrolyte is in a solid state while inactive. To activate, heat is applied to this electrolyte, melting it and putting the battery into active output condition.

Thermonuclear -- Two-stage reaction, with a fission device exploding and starting a fusion reaction in light elements.

Thyratron -- A grid-controlled electron tube.

Tritium -- The hydrogen isotope of mass number 3.

Uranium-235 -- A radioactive element, an isotope of uranium-238.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent uranium-238; the rest is uranium-235.

Warhead -- A weapon carried to the target by missile.

X-Unit -- A device used to provide high voltage to the weapon detonators.

Yield -- The measure of the effect of a nuclear detonation compared to the effect of an explosion of TNT.

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